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FINAL TECHNICAL REPORT

For Work Done Under

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For The

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

409 626

On

THE DETERMINATION OF OPTICAL EXCITATION CROSS-SECTIONS IN ATOMIC GASES AND DETERMINATION OF CROSS-SECTIONS FOR ATOMIC COLLISIONS. A: EXPERIMENTAL: B: THEORETICAL,

This research was supported by the General Physics Division, AFOSR, SRPP under Contract/Grant No. 62-66 & 62-67

By

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EXPERIMENTAL

The experimental work on the determination of excitation of atoms by electronic impact and by atomic impact was confined to electron-helium and helium-helium impacts.

Rather extensive excitation measurements were made on six families of helium energy levels studied by the observation of radiation from them were:

Family	Principle Quantum Number, n
Singlet S	4, 5, 6
Singlet P	3, 4
Singlet D	4, 5, 6
Triplet S	4, 5
Triplet P	3
Triplet D	3, 4, 5, 6

These measurements of apparent excitation cross section were made with electrons of energies varied from 0 to 500 electron volts. Pressures ranged from 1×10^{-3} Torr. to 2×10^{-1} Torr. for the more intense lines and down to 10^{-2} Torr. for the weaker lines. The measurements made at the lower pressures yield data on the excitation of helium by electron impact while the data at the high pressures gives information on collision cross sections of excited atoms with neutral atoms in addition to information on electron-atom collision cross sections.

Results of excitation to the 4^1D, 3^3D, and 4^3D states are printed in THE PHYSICAL REVIEW 128, 1749-1753 (Nov. 15, 1962). This article describes the interesting features and processes of transfer of excitation from the singlet P states to the singlet D and triplet D states via the F states.

Another transfer phenomenon showing transfer into the triplet P states from the singlet D states was presented at the Gaseous Electronics Conference held at Boulder, Colorado on October 10-12, 1962, paper J-1. A second publication entitled "System for Processing and Recording Excitation Function Data" appeared in THE REVIEW OF SCIENTIFIC INSTRUMENTS 33, 1089-1094 (Oct. 1962). This paper describes in detail the new automatic data processing and recording system used in the analysis of the excitation data. The new system is capable of producing data faster and of better quality than the older manual method. Furthermore, it has allowed us to extend our measurements to many energy levels which previously were inaccessable due to their low intensity light yield. As the data on these levels becomes more complete they will be published in scientific journals.

THEORETICAL

A method for the calculation of inelastic cross section for an electron-atom collision under near-resonance condition has been developed. By means of the standard partial-wave method, the Schroedinger equation can be reduced to a series of pair wise coupled differential equations. These coupled equations are solved by an iterative procedure using the solution of the corresponding exact-resonance problem as the zero-th order approximation. This method has been applied to the calculation of transitions of the type $nS \rightarrow nP$ ($\Delta S = 0$). In the case of $2^1S \rightarrow 2^1P$ and $2^3S \rightarrow 2^3P$ transitions in He atoms, the partial cross sections calculated by this method approach those of Born approximation for $\ell > 12$,

but are appreciably smaller for ℓ less than 9.

Analysis of the population of the 4^1D and 4^3D states due to collisional excitation transfer from the n^1P via the nF states have been made. The atom-atom collision cross sections were calculated by applying Stueckelburg's method in the same manner as our previous work [Lin and Fowler, Ann. Phys. 15, 461 (1961)]. The results of the theoretical analysis of the population of the 4^1D and 4^3D states agree well with the experimental value and provide strong support to the multiple state transfer process. This work has been published in the PHYSICAL REVIEW along with the experimental findings (see the previous section).

GRADUATE STUDENTS INFORMATION

1. During the year two men working on the project of excitation measurements completed the requirements for the M.S. degree in Physics. Mr. Harold West is now working as a research physicist with Minneapolis Honeywell Regulator Company, Minneapolis, Minnesota. Mr. Richard L. Stanton, the second graduate, is employed by Autonetics, Division of North American Aviation, Inc., Downey, California.

2. Three physics graduate students are currently engaged in the experimental research work. They are Mr. Frank Miller and Mr. Ray Sims, Ph.D. candidates and Mr. Ronald L. Kassik, an M.S. candidate. All are energetic men devoted to their research and academic goals.

3. Mr. Neal Lane has been working on the theoretical aspect of this project. Mr. Lane received His M.S. degree in June 1962 and is currently working toward his Ph.D. degree. His M.S. thesis deals with the problem of electron-atom inelastic collision under near-resonance

PUBLICATIONS (Experimental and Theoretical)

1. R. M. St. John, C. C. Lin, R. L. Stanton, H. D. West, J. P. Sweeney, and E. A. Rinehart, "System for Processing and Recording Excitation Function Data", Rev. Sci. Instr. 33, 1089 (1962).

2. C. C. Lin and R. M. St. John, "Collisional Excitation Transfer to the 4^1D State in Helium by Multiple State Mechanism", Phys. Rev. 128, 1749 (1962).

3. R. M. St. John, "A System for Processing and Recording Excitation Function Data", a paper presented in the American Physical Society meeting, February 23-24, 1962, Austin, Texas; abstract published in Bull. Am. Phys. Soc. II 7, 115 (1962).

4. C. C. Lin and R. M. St. John, "Collisional Excitation Transfer to the 4^3D State in Helium", a paper presented at the 15th Annual Gaseous Electronics Conference, October 10-12, 1962, Boulder, Colorado.

5. R. M. St. John and C. C. Lin, "Pressure Dependence of Excitation Functions of Triplet S and P States in Helium", a paper presented at the 15th Annual Gaseous Electronics Conference, October 10-12, 1962, Boulder, Colorado.

6. F. F. Lane and C. C. Lin, "Cross Sections for Inelastic Collisions under Near-Resonance Condition - 2S-2P Transitions in He by Electron Impact", a paper presented at the 15th Annual Gaseous Electronics Conference, October 10-12, 1962, Boulder, Colorado.